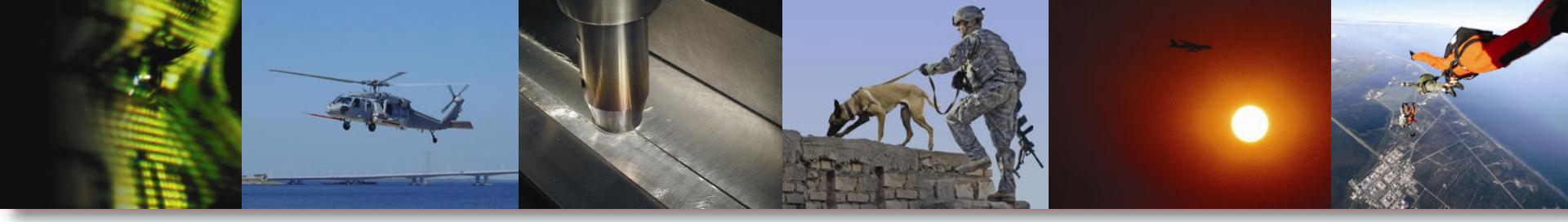

Environment, Energy Security, and Sustainability (E2S2) Symposium and Exhibition

Microgrid with Solar Power and Fuel Cell Technology

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Report Documentation Page

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OVERVIEW

- Background
- Terminology
- Project Objective
- Requirements
- Microgrid System
- Planned Testing

Background

- One of the primary energy challenges identified in the February 2008 Defense Science Board Task Force on Department of Defense (DoD) Energy Strategy was
  - "Military installations are almost completely dependent on a fragile and vulnerable commercial power grid, placing critical military and homeland defense missions at unacceptable risk of extended power outage."
- Tasked by the United States Air Force (USAF) Advanced Power Technology Office (APTO) to develop a Microgrid using Solar Panels and Fuel Cell Technologies

Terminology

- General Definition
  - An integrated energy system consisting of interconnected loads and distributed energy resources that can operate in parallel with the grid or in an intentional island mode.
- Key Defining Characteristics
  - Integrated distributed energy resources (DERs), capable of providing sufficient and continuous energy to mission critical loads
  - Independent controls; island and reconnect with minimal disruption
  - Flexible configuration and operation of the power delivery system
  - Optimized local DERs, large network loads, and broader power system

Project Objective

- Design, integrate, test and sustain a DC based 50 kW microgrid with multiple power sources which will demonstrate:
  - Reliably supply power to dedicated loads in a prioritized fashion
  - Supply excess power to the grid, when appropriate
  - Make intelligent decisions when the PV array (and other sources) should directly supply power to the load
  - Make intelligent decisions when the PV array (and other sources) should supply power to charge the battery energy storage system
  - Make intelligent decisions when none of the options are available and allow the load to be sourced via a grid connection or the government furnished back-up generator.

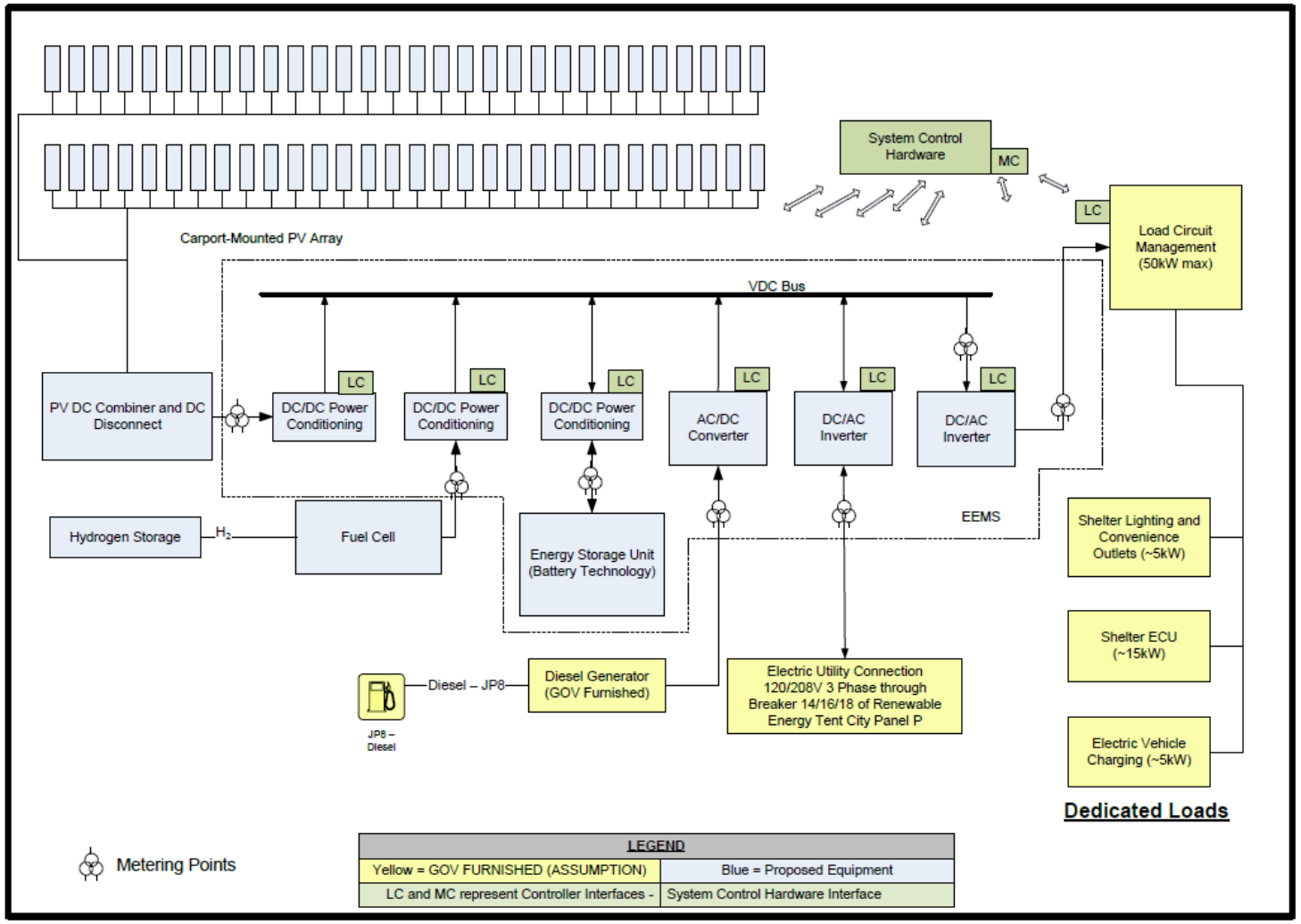
Requirements

- Ability to run grid tied or islanded
- High reliability electrical supply to identified loads
- Load prioritization
- Effectively manage energy storage to maximize energy supply to critical loads
- Control system to monitor loads and sources, and effectively manage these loads and sources to attain high reliability supply to critical loads
- Data collection to determine metrics of system operation
- Supply a maximum of 50 kW output

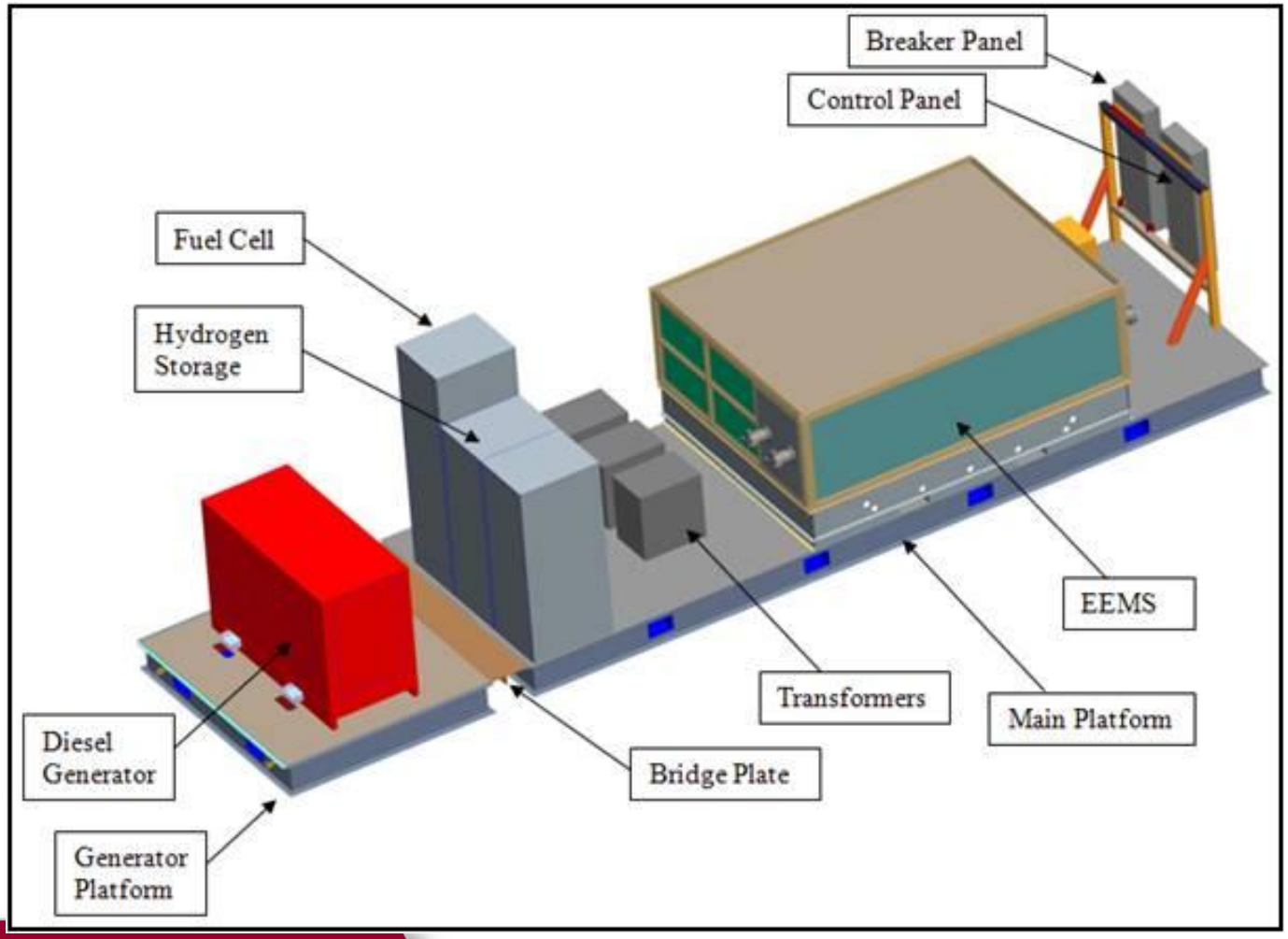
Requirements - Site

- Environmental and weather concerns
  - Lightning protection
- Stand-off distances from tents and specific equipment
- Footprint, size, and overall weight of equipment
- Ability to cover, conceal, and protect interconnecting wiring and cable from damage or safety concerns

Microgrid System – Schematic View

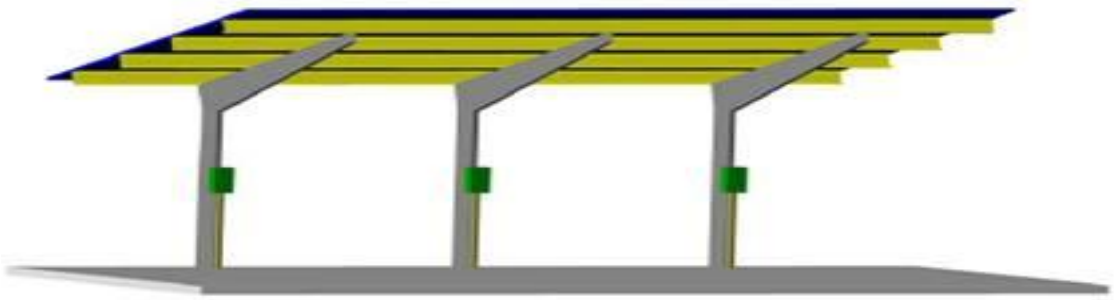


Microgrid System – Layout



Microgrid System Sources – PV Array

- 140 individual 175 W modules
- 14 strings of ten modules each
- Peak power rating of 24.5 kW @ an operating voltage of approximately 360 VDC
- Footprint 111’ x 20’



Microgrid System Sources – Fuel Cell

- 5 kW output
- 48VDC
- Proton Exchange Membrane (PEM)
- Up to 16 hours of full load operation w/ fuel storage

Microgrid System Sources – Diesel Generator

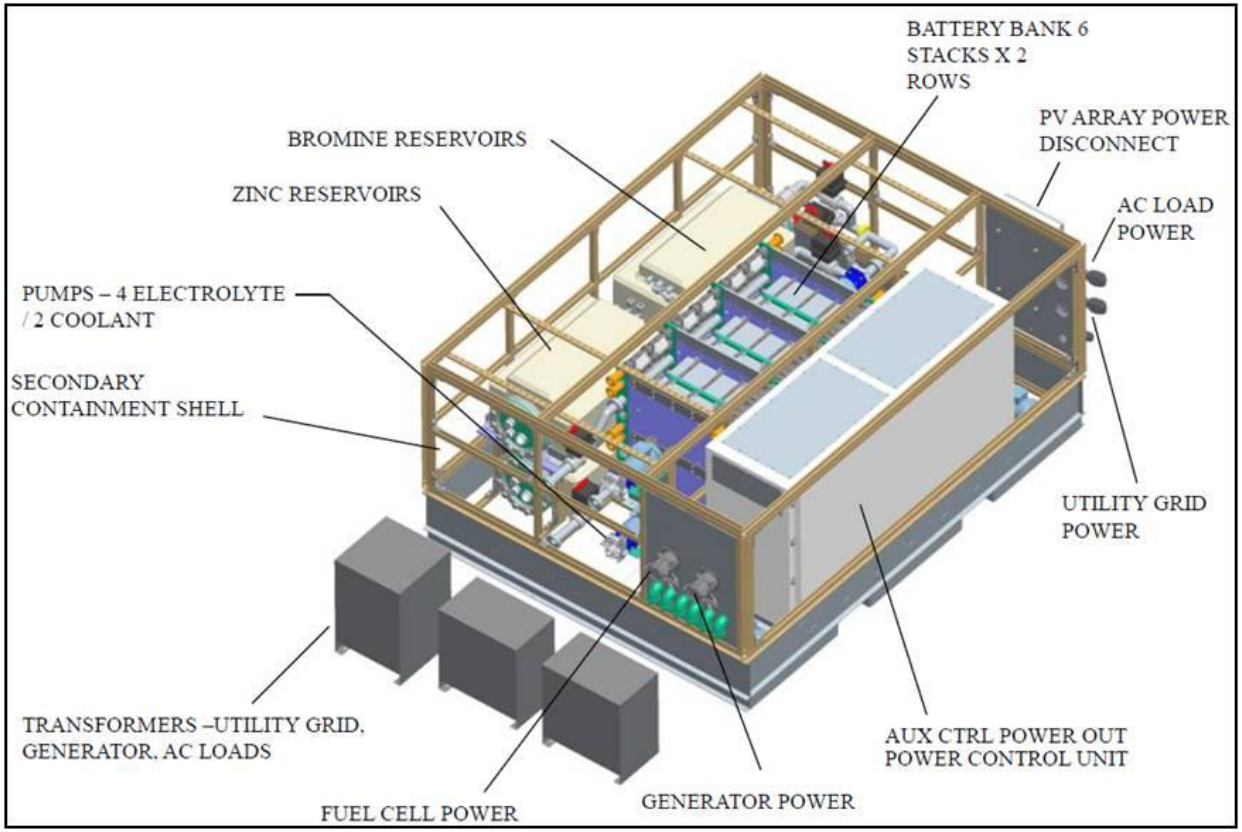
- MEP-805A generator
  - 30 kW, 120/208 volts AC (VAC), 3 phase, 60 Hz

Microgrid System Sources – Energy Storage

- Selected Zinc Bromide:
  - Improved cycle life; 30 years before stack replacement
  - Reasonable round-trip efficiency (70-80%)
  - Deep cycle (allows full capacity from 100% to 0% charge)
  - Environmentally acceptable
  - Commercial units - scalable to large systems
- 100kWhr/50kW capacity

Microgrid System Sources – Electrical Energy Management System

- Flow battery
- Source power conditioning
- Output power conditioning
- Isolation transformers
- Metering



- 1741 compliant 200 Amp electrical utility connection point

Microgrid Control System

- Programmable Logic Controller based supervisory control.
- PC-based operator interface and data acquisition to provide oversight, configure testing, and capture operational data.

Microgrid Loads

- Environmental Control Unit (ECU) 17 kW
- Lighting 1.8 kW
- Convenience Receptacles 3.6 kW
- EV Charging Receptacles 6 kW
- Control Power / Control Panel AC < 4 kW

Microgrid Testing

- Determine and quantify operations performance characteristics
  - Efficiency of various components to produce or process energy
  - Quantifying the reliability of the microgrid configuration
  - Validate the benefits of energy storage
  - Prioritized load management

Microgrid Testing

- Interaction of subsystems
  - Diesel Generator Load changes w/ energy storage
  - Diesel Generator Efficiency w/ & w/o energy storage
  - Islanded PV and energy storage
  - Control system and algorithms

Benefits

- Improved Reliability
  - Critical load support
  - Integration of multiple generation sources (legacy and renewable)
- Risk Mitigation / Improved Energy Security
  - Eliminate dependence upon local utility
  - Integrating available energy sources for backup power
- Electrical Cost Reduction
  - Intelligent control for peak shaving
  - Renewable Energy Integration
  - Improved asset utilization by integrating distributed sources

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